ECE 659 Quantum Transport: Atom to Transistor

Lecture 17: Non-Coherent Transport

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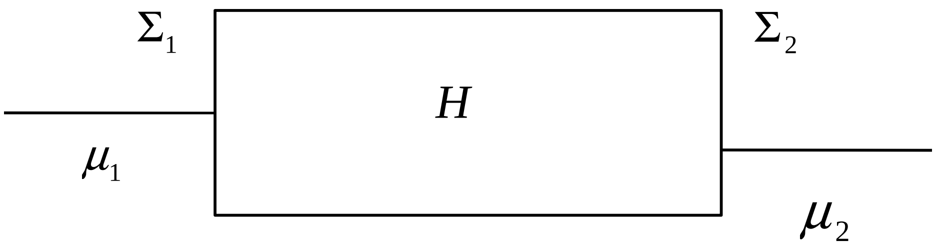


$$\Gamma = i\left[\Sigma - \Sigma^{+}\right]$$

$$G = \left[EI - H - \Sigma\right]^{-1}$$

$$G^{n} = G \underbrace{\Sigma^{in}}_{\Gamma_1 f_1 + \Gamma_2 f_2} G^{+}$$

$$A = i\left[G - G^{+}\right] = G\Gamma G^{+} = G^{+}\Gamma G$$

$$G^{n} = 2\pi\psi\psi^{+}$$

$$\Sigma^{in} = 2\pi s s^{+}$$

$$E\psi = \underbrace{H\psi + \Sigma\psi + s}_{\Phi}$$

$$I_{op} = \frac{\Phi\,\psi^{+} - \psi\,\Phi^{+}}{i\hbar}$$

$$i\hbar\frac{d\tilde{\psi}}{dt} = \tilde{\Phi}$$

current → $\frac{d}{dt}\left(\tilde{\psi}\tilde{\psi}^{+}\right)$

To get total current we need to take the Trace of I_{op}

$$Trace\left[I_{op}\right] = \frac{1}{2\pi} Trace\left[\frac{H\overbrace{\psi\psi^{+}}^{G^{n}} - \overbrace{\psi\psi^{+}}^{G^{n}}H}{i\hbar}\right]$$

$$= \frac{1}{ih} Trace\left[HG^{n} - G^{n}H\right]$$

$$= 0$$

$$\Phi = \Sigma\psi$$

$$I_{op} = \frac{\Sigma\psi\psi^{+} - \psi\psi^{+}\Sigma^{+}}{2i\pi\hbar}$$

$$Trace\left[I_{op}\right] = \frac{1}{ih} Trace\left[\Sigma G^{n} - G^{n}\Sigma^{+}\right]$$

$$= \frac{1}{ih} Trace\left[\left[\Sigma - \Sigma^{+}\right]G^{n}\right]$$

$$Trace\left[I_{op}\right] = \frac{-Trace\left[\Gamma G^{n}\right]}{h}$$

$$\Phi = s$$

$$I_{op} = \frac{s\psi^{+} - \psi s^{+}}{i\hbar}$$

$$\psi = Gs$$

$$I_{op} = \frac{\overbrace{ss^{+}}^{\frac{\Sigma^{in}}{2\pi}} G^{+} - Gss^{+}}{i\hbar}$$

$$Trace\left[I_{op}\right] = Trace\frac{\Sigma^{in}G^{+} - G\Sigma^{in}}{ih}$$

$$= \frac{Trace\left[\Sigma^{in}\left(G^{+} - G\right)\right]}{ih}$$

$$= \frac{Trace\left[\Sigma^{in}A\right]}{h}$$

Total current:

$$Trace\left[I_{op}\right] = \frac{Trace\left[\Sigma^{in}A - \Gamma G^{n}\right]}{h}$$

$$\Gamma = \Gamma_{1} + \Gamma_{2}$$

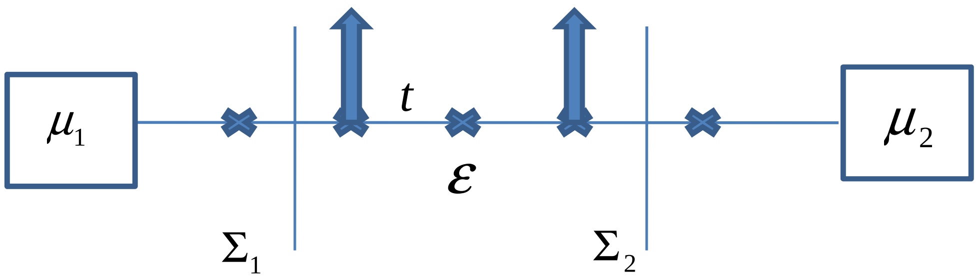
$$\Sigma^{in} = \Gamma_{1} f_{1} + \Gamma_{2} f_{2}$$

For current at each terminal we can use the subscripted expression:

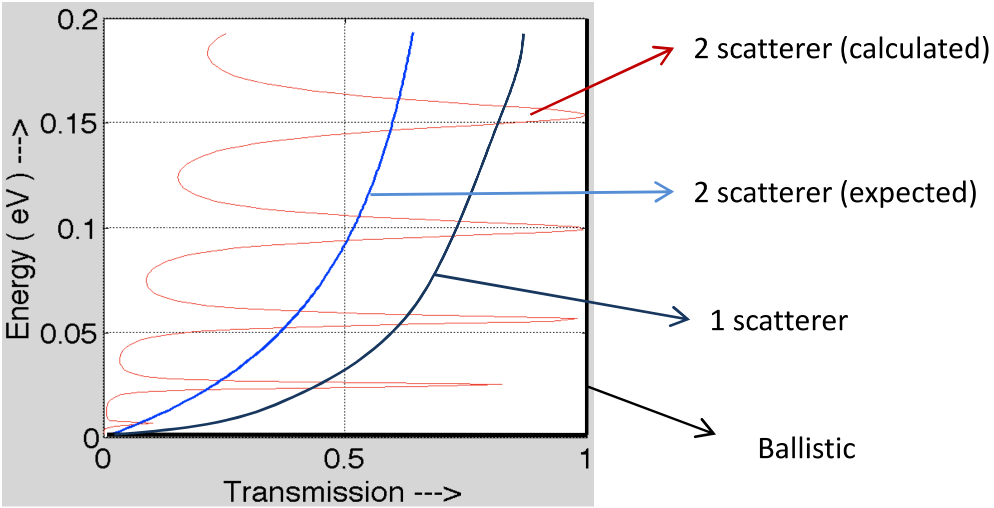
$$I_{m} = \frac{q}{h} Trace\left[\Sigma_{m}^{in}A - \Gamma_{m}G^{n}\right]$$

$$I_{m} = \frac{q}{h} Trace\left[\Gamma_{m}\left(Af_{m} - G^{n}\right)\right]$$

Scatterer



μ_1
t
ε
Σ_1
Σ_2
μ_2



0.2
0.15
0.1
0.05
0
Energy (eV) --->
0
0.5
1
Transmission --->
2 scatterer (calculated)
2 scatterer (expected)
1 scatterer
Ballistic